55.5 / 167

Northwest and Alaska Fisheries Center

Resource Assessment & Conservation Engineering

7600 Sand Point Way NE

BIN C15700, Bldg. 4

Seattle, WA 98115

CRUISE RESULTS

NOAA Ship Miller Freeman

CRUISE NO. 84-4

Eastern Bering Sea Age 0 Walleye Pollock

Echo Sounder-Midwater Trawl Survey

July 30-August 30, 1987

The NOAA ship Miller Freeman, a 215 foot stern trawler, returned to Dutch Harbor August 20, 1984, after completing a three week survey of the eastern Bering Sea shelf and continental slope between Unimak Pass and 62° N. Latitude.

ITINERARY

July 30	Departed Dutch Harbor and commenced survey;
July 30-August 13	Conducted systematic survey of shelf and

	continental slope of Eastern Bering Sea between Unimak Pass and 62°N;
August 13-August 20	Conducted additional transects and trawl sampling to further delineate aggregations of age 0 pollock observed during the systematic survey; transit to Dutch Harbor.

OBJECTIVES

The primary objective of this survey was to collect echo sounder (color scope) records and midwater trawl data necessary to determine the distribution, relative abundance, and biological composition of the off-bottom component of the age 0 pollock population in the eastern Bering Sea. The cruise was part of a continuing effort to study the recruitment patterns of age 0 pollock in the eastern Bering Sea.

A secondary objective was to investigate the reliability of two different methods for determining the distribution of age 0 pollock concentrations. The first involved estimating relative densities from the color echosounder output. The other used catch per unit effort (CPUE) obtained from selected trawl hauls.

Relative density estimates derived from the color sounder and CPUE values should be directly proportional if the following assumptions hold. First, the echo sign is correctly interpreted to be due to age 0 pollock. Second, the trawl is accurately fished so it passes through the indicted concentrations of age 0 pollock. Also, net performance and fish reaction to the net remain consistent.

Any departure from these assumptions make comparisons between the two distribution pattern less reliable.

EQUIPMENT

Acoustic data were collected using a 38kHz echo sounder interfaced to a color scope display. Each of the eight colors in the display represented a different range of echo densities.

Trawl sampling for age 0 fish was done using a Marinovich midwater trawl (Fig. 1) with 5x7 foot steel V-doors. The trawl mouth is square with headrope, footrope, and breastline lengths of 30 feet. Stretched mesh sizes range from 3 inches forward to 1 1/8 inches in the cod end. The final third of the cod end was lined with a 3/8 inch knotless nylon net during all trawl hauls (Configuration 1, Fig. 1). From August 5 to 10, a 1/8 inch knotless nylon net was placed around the outside of the cod end and attached to the intermediate, just forward of the cod end (Configuration 2, Fig. 1). On August 10, the 1/8 inch mesh was destroyed and the net was again fished for a short time using Configuration 1. On August 14, a 1/8 inch mesh knotless net was attached between the 3/8 inch inner liner and the cod end proper. It covered the final third of the cod end, similar to the 3/8 inch mesh netting (Configuration 3 Fig. 1). This final arrangement was in place during all Marinovich tows for the remainder of the survey.

A large midwater trawl (Diamond 1000) was also fished at selected locations. This was done to either identify echo sign from other than age 0 fish or to find potential sites for a pollock cannibalism study scheduled to begin August 24, 1984. The Diamond 1000 trawl is a square midwater trawl with headrope, footrope, and breastline lengths of 177 feet. Stretched mesh sizes range from 32 inches forward to 3 1/2 inches in the cod end. A 1 1/4 inch mesh liner was installed in the cod end. The Diamond was fished with 5x7 foot steel doors and 30 fathom dandy lines.

Both nets were positioned using a cable wire net sounder system. The average vertical mouth openings of the Marinovich and Diamond trawls were 2-3 fathoms and 9-10 fathoms respectively.

METHODS

Acoustic analysis

The systematic survey was conducted 24 hours per day along a trackline pattern consisting of 10 parallel transects. Spacing between transects was approximately 60 nm. The entire systematic survey was carried out between the 15 and 250 fathom isobaths (Fig. 2). Trawl hauls were made at approximately 60 nm intervals along the transects. Additional acoustic and trawl sampling was conducted in areas where the abundance of the age 0 pollock was high.

The different densities of detected targets were indicated by eight separate colors on the color scope. The voltage range of each color was determined during pre-cruise equipment testing and a mean voltage, $\underline{V}_i$, calculated for each color. All mean voltages were then normalized to the first voltage by $V_i=\underline{V}_i/\underline{V}_1$, where $\underline{V}_i$ was the mean voltage of the ith color (Table 1). During the cruise, the color scope was periodically re-calibrated to ensure that the voltage ranges for each color remained constant.

Estimations of the proportion of each color from the color scope display were made at hourly intervals. The required time varied gain (TVG) setting necessary for density estimates, $20\log R+2\alpha R$, was approximated as closely as possible with the controls available on the echo sounder. Since the square of the voltage of a received echo signal is proportional to target density, it was necessary for the normalized voltage, V_i, to be squared before relative densities could be calculated.

Relative density estimates of the echo sign were made from the hourly readings as follows:

$$d = \sum_{i=1}^{8} \frac{P_i (V_i)^2}{100} * \frac{R}{1000}, \text{ where}$$

R = depth extent of echo sign in meters,

V_i = mean voltage of color i, normalized to V_1, and

P_i = estimated proportion of color i in depth range R.

<u>CPUE analysis</u>

Relative density estimates, d, derived from the color sounder output near trawl locations were compared with the CPUE values from the hauls. The primary purpose of the comparison was to determine the degree to which the relative density estimates from the color scope were indicative of age 0 pollock abundance. Since the color echo sounder was being used with the net sonde during trawling, estimations of percent of echo sign at each color level (and subsequent relative density determinations) could not be made at the exact haul position. The relative density index of age 0 pollock for a trawl haul was calculated by using the estimated percentages from the color sounder readings obtained closest to the trawl location. If the echogram made nearest to the trawl position and the one obtained during the trawl haul appeared similar, the resulting relative density estimate was assumed to be representative of the trawl haul. If there was not enough similarity, no relative density was designated for that haul. This procedure eliminated 16 of the 50 Marinovich trawls from further analysis.

For each trawl haul that was acceptable, two estimates of CPUE of age 0 pollock were calculated: 1) $CPUE_n$, based on the numbers of age 0 pollock caught and 2) $CPUE_b$, an estimation of the biomass of age 0 pollock.

$CPUE_n$ was calculated as follows:

$$CPUE_n = \frac{N*R}{D*P*H},$$

where N is the number of age 0 pollock caught, D is the distance trawled in meters, P is the assumed width of the mouth opening of the trawl (6.1 m), H is the assumed height of the mouth opening of the trawl (6.1 m), and R is the depth extent of the echo sign, in meters. The $CPUE_n$ value represents the estimated number of age 0 pollock per m^2 of surface area.

$CPUE_b$ was obtained using:

$$CPUE_b = \frac{W*R}{D*P*H}$$

W is the weight of age 0 pollock captured in pounds. $CPUE_b$ is an estimation of the pounds of age 0 pollock per m^2 of surface area.

RESULTS

The Miller Freeman covered a total trackline distance of 4,514 nm. on 26 different transect lines (Fig. 2) and completed 65 midwater trawl hauls (Figs. 3 and 4). A list of species caught is provided in Table 2. Catch data by haul and net type are summarized in Tables 3 and 4. Hauls 1-39 and the first ten transects were carried out during the systematic portion of the survey. Hauls 40-65 and transects 11-26, completed during the latter portion of the cruise, were dedicated to further delineation of the distribution of age 0 pollock. The $CPUE_n$ for all Marinovich hauls containing age 0 pollock are listed in Table 5. A total of 48 CTD (conductivity, temperature and depth) casts and 22 XBT (expendable bathythermograph) casts were made.

There was an increase in the range of $CPUE_n$ values as the relative density, d, increased (Fig. 5). A linear regression run on this data resulted in a correlation coefficient of .64. Possible reasons for the increased variation with increasing values are: 1) variation of the percentages assigned to each color among the various observers, 2) poor net performance, which would account for low $CPUE_n$ in an area of high relative density, 3) the net passing through the denser patches of fish though the average relative density estimate was low , or 4) fewer but larger fish in the echo sign. When $CPUE_b$ values were plotted against relative density (Fig. 6), the correlation coefficient increased to 0.80. This would imply that aggregations of age 0 pollock with the same biomass would return the same amount of energy though their absolute numbers may be different.

Since many hauls contained a significant proportion of jellyfish, a comparison of relative density with total $CPUE_b$ for all organisms in the catch was made (Fig. 7). This was done to find out if the presence of jellyfish may have effected the relative density estimates. The resulting regression from this data yielded a correlation coefficient of .15. However, when the weight of the jellyfish was removed from the total weight of each catch, the new linear regression showed a correlation coefficient of .78. This is reasonable since the echo return per unit weight from jellyfish is small.

Contour plots of age 0 pollock distribution were made using the $CPUE_n$ (Fig. 8) and relative density data (Fig. 9). There was little agreement between the two distributions within the area bounded by 159° W and 169° W. The echo sign in this area may have been due to organisms other than age 0 pollock which were not effectively sampled by the Marinovich trawl. For example, color scope observations made in the vicinity of hauls 1 and 2 (Fig. 3) indicated dense patches of sign. The trawl hauls contained a low number of age 0 pollock but some adult pollock were caught. The presence of these adult pollock may have accounted for a significant portion of the echo sign.

The inverse also occurred. A higher $CPUE_n$ was obtained in areas of lower relative density. An example of this can be seen in the patch centered around 58° N and 166° W. (Fig. 8). As previously stated, this may have been due to the trawl net passing through the denser concentrations of fish in an area of low average density.

However, both maps showed two dense concentrations of age 0 pollock. One was well inside Bristol Bay, east of 160° W, the other northwest of the Pribilof Islands. Both of these concentrations were in areas where the recorded gear temperatures were greater than 4 °C (Figure 10). Lower densities of fish were consistently encountered when the gear temperature was below 4 °C.

Since three different cod end configurations were used, fish catchability was not constant. Consequently, estimations of the absolute abundance of age 0 pollock should be considered conservative. Two estimates of the number of age 0 pollock in the survey area were made using CPUE data from the 50 Marinovich tows. Assuming 100% trawl efficiency and that the entire fish layer was within the vertical path of the trawl, the unadjusted average areal density ($\overline{CPUE}_{un}$) is:

$$\left(\sum_{i=1}^{50} CPUE_{un(i)}\right)/50 = \overline{CPUE}_{un}; \quad \overline{CPUE}_{un} = 5,917.75/\text{Ha}$$

$CPUE_{un(i)}$ = number/hectare of age 0 pollock in haul i, unadjusted for depth of sign. Total survey area was approximately 80,000 nm2 (27,439,232 Ha.) resulting in a population estimate of 162 billion age 0 pollock.

However, assuming that the age 0 pollock were distributed throughout the water column, the above determination would be fairly conservative. A second estimate was made using the previously calculated $CPUE_n$ values (N*R/D*P*H). This accounted for the variations in depth extent of age 0 pollock aggregations during the survey. The estimated $\overline{CPUE}_n$ was 31,532,555/Ha, resulting in a total age 0 population of 864 billion.

Average length of age 0 pollock determined from all Marinovich trawl hauls was 45.6 mm.

SCIENTIFIC PERSONNEL

Jimmie Traynor	Chief Scientist, NWAFC
Debbie Dwyer	Fishery Biologist, NWAFC
Karen Halliday	Fishery Biologist, NWAFC
Neal Williamson	Statistician, NWAFC

LITERATURE CITED

Burczynski, J. 1979. Introduction to the use of sonar systems for estimating fish biomass. FAO Fish. Tech. Pap., (191):89 pp.

For further information, contact Dr. Gary Stauffer, Director, Resource Assessment and Conservation Engineering Division, Northwest and Alaska Fisheries Center, National Marine Fisheries Service, 7600 Sand Point Way N.E.; BIN C15700; Building 4; Seattle, WA 98115. Telephone (206) 526-4170.

Table 1.--Normalized average voltage and equivalent relative density value for each color on the echo sounder.

Color	Normalized Average Voltage (Vi)	Equivalent 1/ Rel. Density
1	1.00	1.00
2	2.20	4.84
3	3.28	10.76
4	5.50	30.25
5	9.20	84.64
6	15.80	249.64
7	27.80	772.84
8	55.00	3025.00

1/ Theoretically, density is proportional to the output voltage of an echosounder squared. (Burczynski, 1982)

Table 2.--List of species caught in trawl hauls during *Miller Freeman* Cruise 84-4.

Taxa	Common Name	Scientific Name	M1/	D2/
Gadidae	Walleye pollock	*Theragra chalcogramma*	x	x
	Pacific cod	*Gadus macrocephalus*	x	x
Salmonidae	Sockeye salmon	*Oncorhynchus nerka*		x
Cottidae	Bigmouth sculpin	*Hemitripterus bolini*	x	
	Sculpin (unident.)		x	
Pleuronectidae	Juvenile (unident.)		x	x
	Yellowfin sole	*Limanda aspera*	x	x
	Flathead sole	*Hippoglossoides elassodon*		x
Cyclopteridae	Snailfish (juv.)		x	
Zoarcidae	Eelpout (unident.)		x	x
Osmeridae	Capelin	*Mallotus villosus*	x	
Clupeidae	Pacific herring	*Clupea harengus pallasi*	x	
Ammodytidae	Pacific sand lance (juv.)	*Ammodytes hexapterus*	x	
Trichodontidae	Pacific sandfish	*Trichodon trichodon*	x	x
Agonidae	Poacher (unident.)		x	
Cephalopoda	Squid (juv., unident.)		x	x
Decapoda	Shrimp (unident.)		x	
	Crab larvae (unident.)		x	
Scyphozoa	Jellyfish (unident.)		x	x
Euphausiacea	Euphausid		x	
Isopoda	Isopods		x	
Copepoda	Copepods	*Calanus cristatus*	x	
		Calanus sp.	x	
Amphipoda	Amphipods (unident.)		x	
Crustacea	Crab larvae		x	

1/ Marinovich trawl

2/ Diamond trawl

Table 3.--Marinovich trawl haul stations and catch data, Miller Freeman Cruise 84-4.

Haul	Date (1984)	Start Pos. Lat(N	Start Pos. Long(W)	Time of day (GMT+9)	Depth (fm) Gear/bottom	Temp (°C) Surface/gear	Duration (hr)	Dist. fished (nm)	Catch (lbs)					Net Conf. Type
									Pollock (Age 0)	Cod (Age 0)	Pollock (>age 0)	Jelly-fish	Other species	
1	7/31	54°49'	165°38'	0400	18/97	9.2/8.7	0.50	1.56	0.11	0.01	7.1	24.7	.7	1
2	7/31	55°23'	164°24'	1100	43/53	9.1/6.5	0.90	2.26	0.34	0.02	14.0	60.0	<0.01	1
3	7/31	55°59'	162°50'	1800	21/41	11.0/5.0	0.50	1.25	3.65	0.03	9.1	336.6	<0.01	1
4	8/01	56°41'	161°05'	0100	7/36	11.1/7.6	0.50	0.86	3.91	0.30	-	192.1	4.40	1
5	8/01	57°24'	159°17'	0800	17/25	8.2/8.1	0.50	1.24	14.60	-	-	5.9	<0.01	1
6	8/01	57°37'	161°51'	2200	19/26	10.8/3.5	0.30	1.27	0.43	-	-	0.5	0.02	1
7	8/02	57°07'	163°06'	0400	6/32	10.0/9.7	0.50	1.35	6.80	0.60	-	167.2	23.20	1
8	8/02	56°45'	163°58'	0800	26/38	10.2/1.6	0.40	1.76	18.90	1.60	-	473.4	0.70	1
9	8/02	56°22'	164°55'	1300	9/46	10.3/10.3	0.50	1.22	26.80	2.20	-	306.4	-	1
10	8/02	56°22'	164°56'	1500	32/46	10.3/1.4	0.50	1.33	0.63	0.02	-	60.5	-	1
11	8/03	55°32'	166°56'	0100	8/74	10.1/10.1	0.50	1.43	3.90	0.23	-	168.8 0	.02	1
12	8/03	56°34'	167°32'	1300	26/58	9.8/2.7	0.50	1.80	2.66	0.25	-	158.0	-	1
13	8/03	57°02'	166°20'	1900	27/39	9.4/4.9	0.70	1.61	1.72	0.02	-	27.5	3.42	1
14	8/04	57°34'	165°04'	0000	10/33	9.7/9.5	0.50	1.46	9.23	0.04	-	11.0	11.73	1
15	8/04	57°55'	164°08'	0400	7/24	9.0/9.0	0.50	1.30	1.77	<.01	-	-	3.10	1
16	8/04	58°11'	163°19'	0800	13/20	8.3/7.8	0.50	1.27	0.63	-	1.6	-	1.94	1
17	8/04	58°23'	165°56'	2100	16/22	8.7/4.9	0.33	0.97	12.20	-	-	0.5	0.38	1
18	8/05	58°00'	167°01'	0000	8/33	9.0/8.3	0.50	1.34	0.22	0.01	-	42.9	7.83	1
19	8/05	57°33'	168°14'	0600	11/37	10.0/8.6	0.33	0.93	2.90	-	-	451.1	4.52	1
20	8/05	57'08'	169°19'	1000	11/38	9.9/8.5	0.50	1.22	4.40	0.04	-	79.8	0.01	1
21	8/05	56°50'	170°07'	1400	23/44	10.0/4.2	0.50	1.30	2.42	0.02	-	17.4	0.24	2
22	8/06	56°52'	172°49'	1200	46/71	9.6/3.5	0.50	1.27	10.80	-	-	20.9	0.21	2
23	8/06	57°30'	171°40'	2000	33/56	10.1/2.7	0.37	0.97	2.36	-	-	16.4	0.87	2
25	8/07	57°53'	170°40'	0200	13/42	9.1/8.4	0.50	1.30	21.60	-	-	134.8	14.22	2
26	8/07	58°16'	169°42'	0600	10/37	9.4/9.1	0.50	1.29	0.54	.24	-	92.4	21.57	2
27	8/07	59°01'	170°53'	2000	22/40	9.0/-0.5	0.53	1.41	1.19	-	-	10.7	0.42	2
28	8/08	57°46'	170°42'	1500	36/42	9.7/2.8	0.33	0.82	44.20	-	-	10.0	14.91	2
29	8/08	57°47'	170°41'	1700	13/42	9.2/7.0	0.50	1.12	8.30	0.10	-	14.1	8.20	2

Table 3. (cont.)--Marinovich trawl haul stations and catch data, Miller Freeman Cruise 84-4.

Haul	Date (1984)	Start Pos. Lat(N	Long(W)	Time of day (GMT+9)	Depth (fm) Gear/bottom	Temp (°C) Surface/ gear	Duration (hr)	Dist. fished (nm)	Catch (lbs) Pollock (Age 0)	Cod (Age 0)	Pollock (>age 0)	Jelly-fish	Other species	Net Conf. Type
31	8/09	58°36'	171°58'	0500	9/52	9.6/8.5	0.42	0.98	19.80	0.24	-	22.90	8.98	2
32	8/09	58°19'	172°45'	1100	30/58	9.3/2.7	0.67	1.28	1.59	<.01	-	8.50	1.25	2
34	8/09	57°58'	173°43'	1800	40/68	9.7/3.2	0.50	1.20	1.08	-	-	4.20	0.72	2
35	8/10	58°44'	174°56'	0400	77/82	9.4/3.4	0.50	1.26	0.05	-	1.0	4.10	2.34	2
36	8/10	59°18'	173°27'	1000	34/57	8.9/1.0	0.50	1.25	0.55	0.02	-	5.94	4.41	2
37	8/10	60°17'	170°46'	1900	13/34	8.7/4.2	0.50	0.94	0.52	-	-	2.41	0.02	2
38	8/11	60°24'	173°57'	1100	28/44	8.3/-1.3	0.50	1.24	0.20	<.01	-	9.50	0.01	1
39	8/12	60°13'	178°00'	0900	69/82	8.6/2.4	0.50	1.30	-	-	63.0	-	-	1
40	8/13	60°37'	178°48'	1500	19/238	4.6	0.50	1.38	.06	-	93.6	-	-	1
41	8/14	59°39'	178°06'	0100	50/88	9.4/3.1	0.50	1.40	0.04	-	4.2	5.30	-	3
42	8/14	59°32'	176°46'	0600	19/80	9.3/7.6	0.33	0.97	0.02	-	13.5	31.60	0.30	3
43	8/14	59°31'	176°45'	0700	62/80	9.3/7.3	0.38	0.96	<.01	-	30.5	27.50	0.05	3
44	8/14	58°35'	173°11'	2300	21/63	9.8/8.2	0.50	1.29	4.87	-	-	36.60	0.09	3
46	8/15	58°26'	171°51'	0600	15/52	10.3/8.8	0.17	0.47	70.29	0.03	-	4.10	0.99	3
48	8/15	57°35'	170°36'	1700	13/40	10.2/8.3	0.17	0.44	22.68	<.01	-	13.20	0.01	3
49	8/15	57°35'	170°37'	1800	35/40	10.2/2.9	0.50	1.39	10.47	-	-	58.10	0.01	3
51	8/17	56°51'	166°42'	0500	11/42	10.9/7.9	0.33	1.10	12.90	1.5	-	433.60	0.41	3
53	8/17	56°49'	165°57'	1000	8/40	11.0/11.0	0.50	1.46	8.26	0.65	-	302.30	0.14	3
54	8/17	56°50'	166°01'	1200	35/40	-	0.50	1.67	3.45	0.46	-	58.50	0.54	3
56	8/18	57°22'	159°27'	0800	18/28	10.3/8.9	0.25	0.73	37.90	0.66	-	80.29	0.12	3
59	8/18	56°32'	161°38'	1900	34/41	11.8/3.0	0.25	0.56	7.0	-	2.0	129.00	-	3
61	8/19	56°16'	162°17'	0200	10/39	11.8/11.8	0.30	0.95	13.34	0.30	-	431.10	2.09	3

Table 4.--Diamond trawl haul stations and catch data, Miller Freeman Cruise 84-4.

Haul	Date (1984)	Start Pos. Lat(N)	Start Pos. Long(W)	Time of day (GMT+9)	Depth (fm) Gear/bottom	Temp (°C) Surface/ gear	Duration (hr)	Dist. fished (nm)	Catch (lbs) Pollock (Age 0)	Cod (Age 0)	Pollock (>Age 0)	Jellyfish	Other species
24	8/06	57°30'	171°39'	2200	26/56	10.1/3.8	0.77	1.90	0.8	0.01	-	52.3	-
30	8/08	57°47'	170°40'	1800	39/42	9.6/2.0	0.50	1.53	4.6	-	0.3	127.3	6.40
33	8/09	58°20'	172°43'	1300	34/57	-	0.50	1.24	-	-	-	1.0	1.00
45	8/15	58°34'	173°09'	0200	60/61	10.0/3.7	0.10	0.22	-	-	354.5	8.2	4.30
47	8/15	58°24'	171°53'	0800	29/53	10.3/2.8	0.25	0.62	.83	<.01	-	16.0	0.04
50	8/15	57°35'	170°36'	2000	38/40	10.2/2.8	0.50	1.46	0.11	-	-	382.9	1.60
52	8/17	56°51'	166°48'	0600	16/42	10.9/2.0	0.25	0.66	0.10	0.53	-	503.9	0.05
55	8/17	56°53'	166°02'	1300	35/40	-	0.50	1.29	0.10	0.10	-	71.0	-
57	8/18	57°23'	159°32'	0900	23/29	10.3/8.9	0.37	1.18	0.40	-	-	10.0	2.70
58	8/18	56°56'	160°42'	1400	33/34	10.4/4.0	0.50	1.13	0.02	-	5.0	-	8.00
60	8/18	56°32'	161°39'	2000	42/44	11.8/3.0	0.30	0.85	-	-	-	256.0	85.20
62	8/19	56°17'	162°20'	0300	16/42	11.8/5.2	0.30	0.87	0.25	-	-	1000.0	4.20
63	8/19	56°17'	162°22'	0400	39/42	11.8/2.9	0.75	2.25	-	-	93.4	600.0	0.50
64	8/19	56°13'	162°20'	0900	23/37	-	0.83	3.03	0.10	0.10	1.0	-	0.00
65	8/19	55°22'	164°23'	1800	46/54	11.5/5.6	0.66	1.90	0.10	-	21.0	305.0	554.00

Table 5.--$CPUE_n$ values from Marinovich catches for MF844 age 0 pollock survey. Hauls 1-39 were part of the systematic survey. Hauls 40-65 were carried out to further delineate age 0 pollock distribution in areas of high abundance. Hauls 40-43 are not included in this analysis since they were targeted on echo sign from pollock > age 0 and captured few age 0 pollock.

Haul #	CPUE (No./Ha)[1/]		
	3/8" liner	1/8" liner	TOTAL
1	151	—	151
2	100	—	100
3	9,198	—	9,198
4	5,434	—	5,434
5	68,801	—	68,801
6	2,585	—	2,585
7	8,356	—	8,356
8	37,147	—	37,147
9	8,940	—	8,940
10	1,511	—	1,511
11	2,801	—	2,801
12	4,191	—	4,191
13	9,633	—	9,633
14	6,769	—	6,769
15	6,772	—	6,772
16	2,160	—	2,160
17	48,594	—	48,594
18	158	—	158
19	1,211	—	1,211
20	5,588	—	5,588
21	10,466	40,433	50,899
22	30,754	50,236	80,990
23	6,386	3,617	10,003
25	15,062	7,151	22,213
26	287	118	405
27	1,325	516	1,841
28	26,359	41,232	67,591
29	5,915	9,092	15,007
31	37,348	40,081	77,429
32	3,339	3,389	6,728
34	889	2,185	3,074
35	46	109	155
36	4,589	971	5,560
37	328	329	657
38	636	—	636
39	0	—	0
AVG[2/]	10,384	14,247	15,925
44	2,604	2,863	5,467
46	168,178	8,999	177,177
48	183,508	16,095	199,603
49	8,396	130	8,526
51	8,887	3,942	12,829
53	1,259	363	1,622
54	4,494	5,435	9,929
56	81,091	5,334	86,425
59	26,759	0	26,759
61	1,621	646	2,267
AVG[3/]	48,680	4,381	53,060

1/ Hauls 1-20 and 38-39 were made using Configuration 1 (Fig. 1); hauls 21-37 used Configuration 2, and 44-61 used Configuration 3.
2/ Average of hauls 1-39 carried out during systematic portion of survey.
3/ Average of hauls 44-61 carried out during non-systematic sampling period

Fig. 1.--Diagram of Marinovich midwater trawl used for sampling age 0 fish.

Fig. 2.--Transect pattern for 1984 age 0 pollock survey. Solid lines are the systematic design. The dashed lines are additional transects completed to survey areas where high abundances were observed during the systematic survey.

Fig. 3.--Trawl station locations of Marinovich trawl hauls for Miller Freeman Cruise 84-4.

Fig. 4.--Trawl station locations of Diamond trawl hauls for Miller Freeman Cruise 84-4.

Fig. 5.--$CPUE_n$ of age 0 pollock versus relative density for selected trawl hauls during Miller Freeman Cruise 84-4.

Fig. 6.--$CPUE_b$ of age 0 pollock versus relative density for selected trawl hauls during Miller Freeman Cruise 84-4.

Fig. 7.--Total $CPUE_b$ versus relative density for selected trawl hauls during Miller Freeman Cruise 84-4.

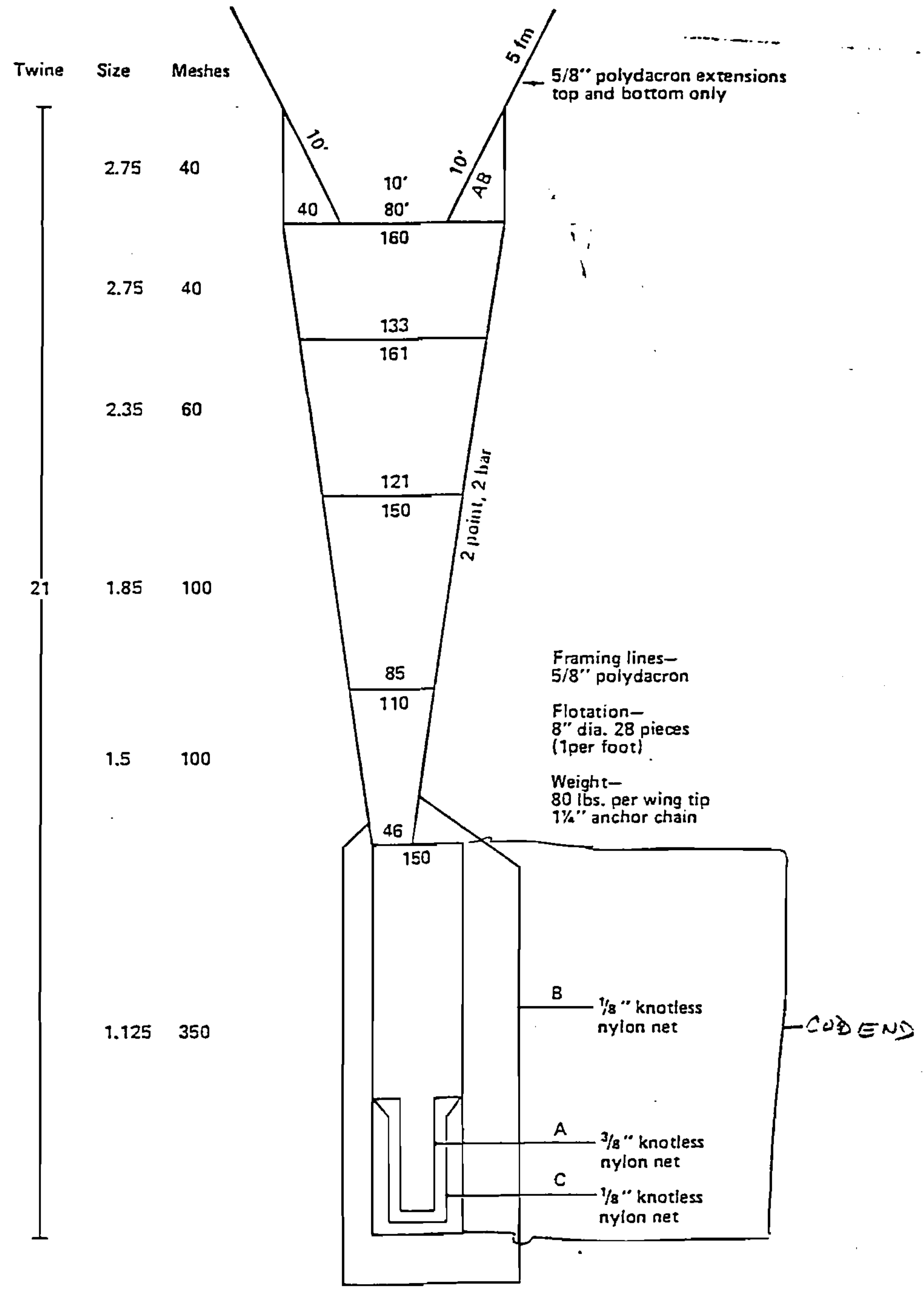
Fig. 8.--Distribution of relative density estimates determined from color sounder measurements during Miller Freeman Cruise 84-4.

Fig. 9.--Distribution of $CPUE_n$ for Marinovich trawl hauls made during Miller Freeman Cruise 84-4.

Fig. 10.-Distribution of gear temperatures observed during Miller Freeman Cruise 84-4.

FIG 1

MIDWATER HERRING TRAWL (4 identical panels)



A = configuration 1
A+B = configuration 2
A+C = configuration 3

FIG. 2

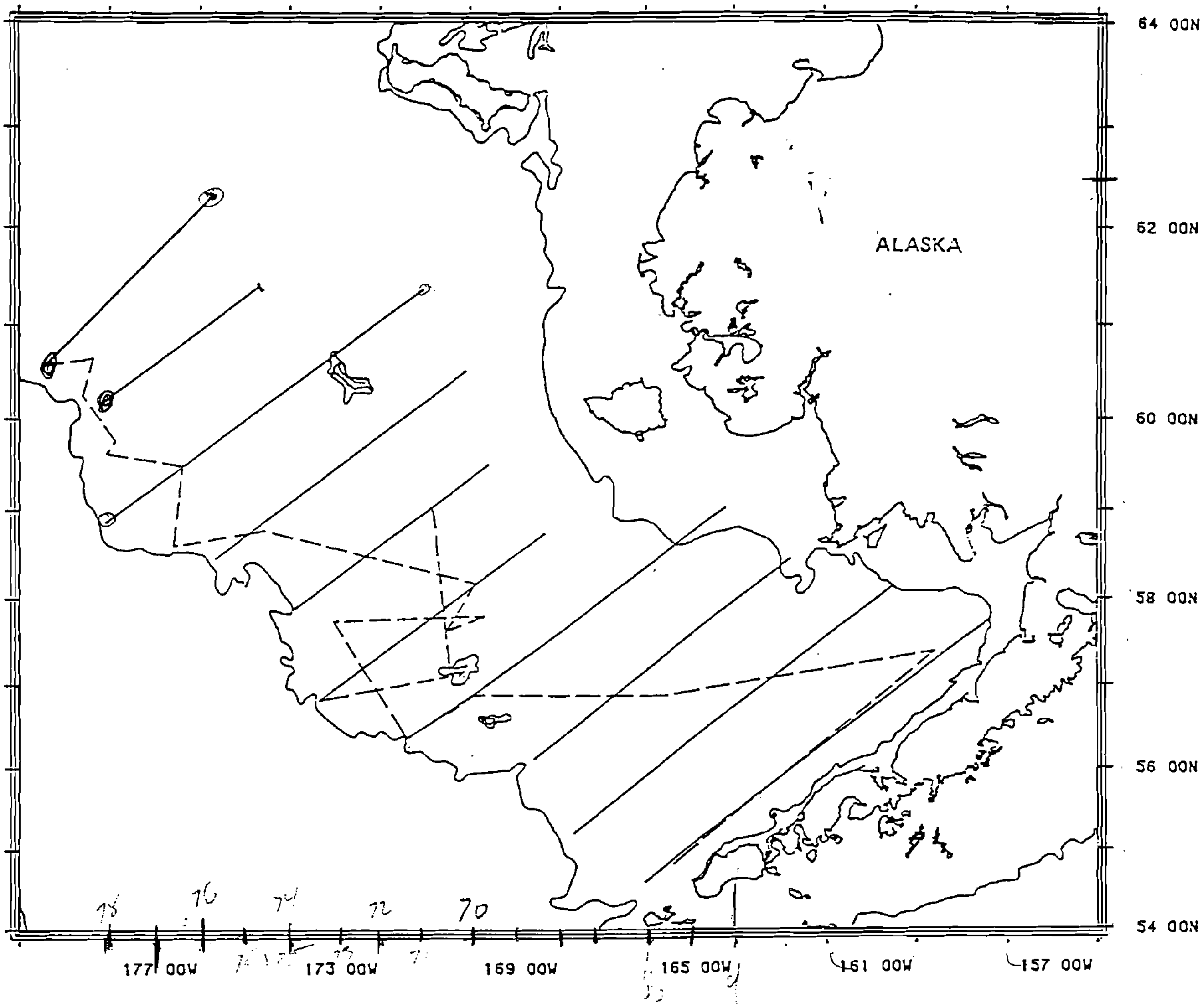
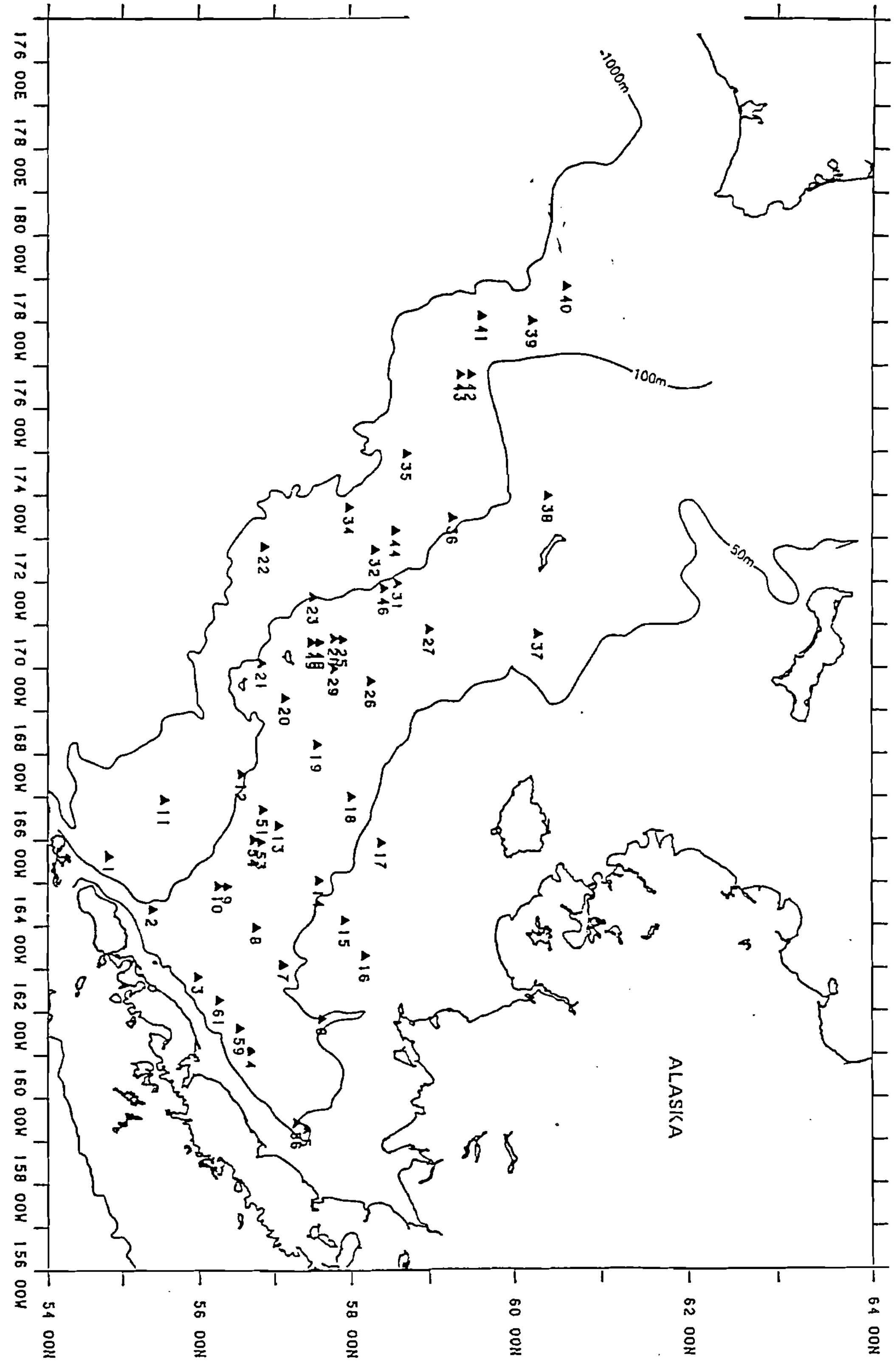

ALASKA
64 00N
62 00N
60 00N
58 00N
56 00N
54 00N
177 00W
173 00W
169 00W
165 00W
161 00W
157 00W

FIG3



176 00E
178 00E
180 00W
178 00W
176 00W
174 00W
172 00W
170 00W
168 00W
166 00W
164 00W
162 00W
160 00W
158 00W
156 00W
54 00N
56 00N
58 00N
60 00N
62 00N
64 00N
1000m
100m
50m
ALASKA

FIG 4

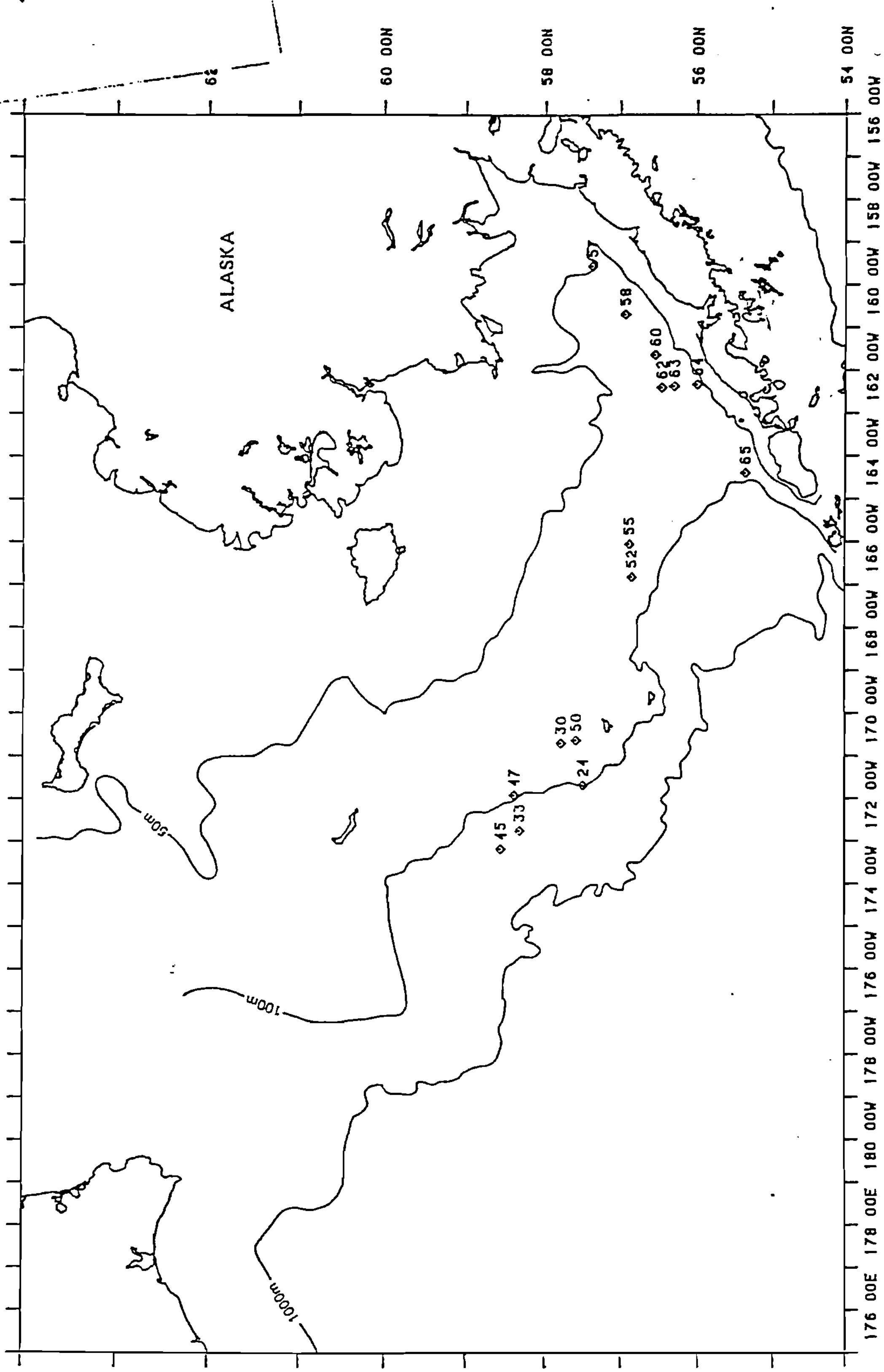

ALASKA
50m
100m
1000m
57
58
60
62
63
61
65
55
52
30
50
24
47
33
45
62
60 00N
58 00N
56 00N
54 00N
156 00W
158 00W
160 00W
162 00W
164 00W
166 00W
168 00W
170 00W
172 00W
174 00W
176 00W
178 00W
180 00W
178 00E
176 00E

FIG 5

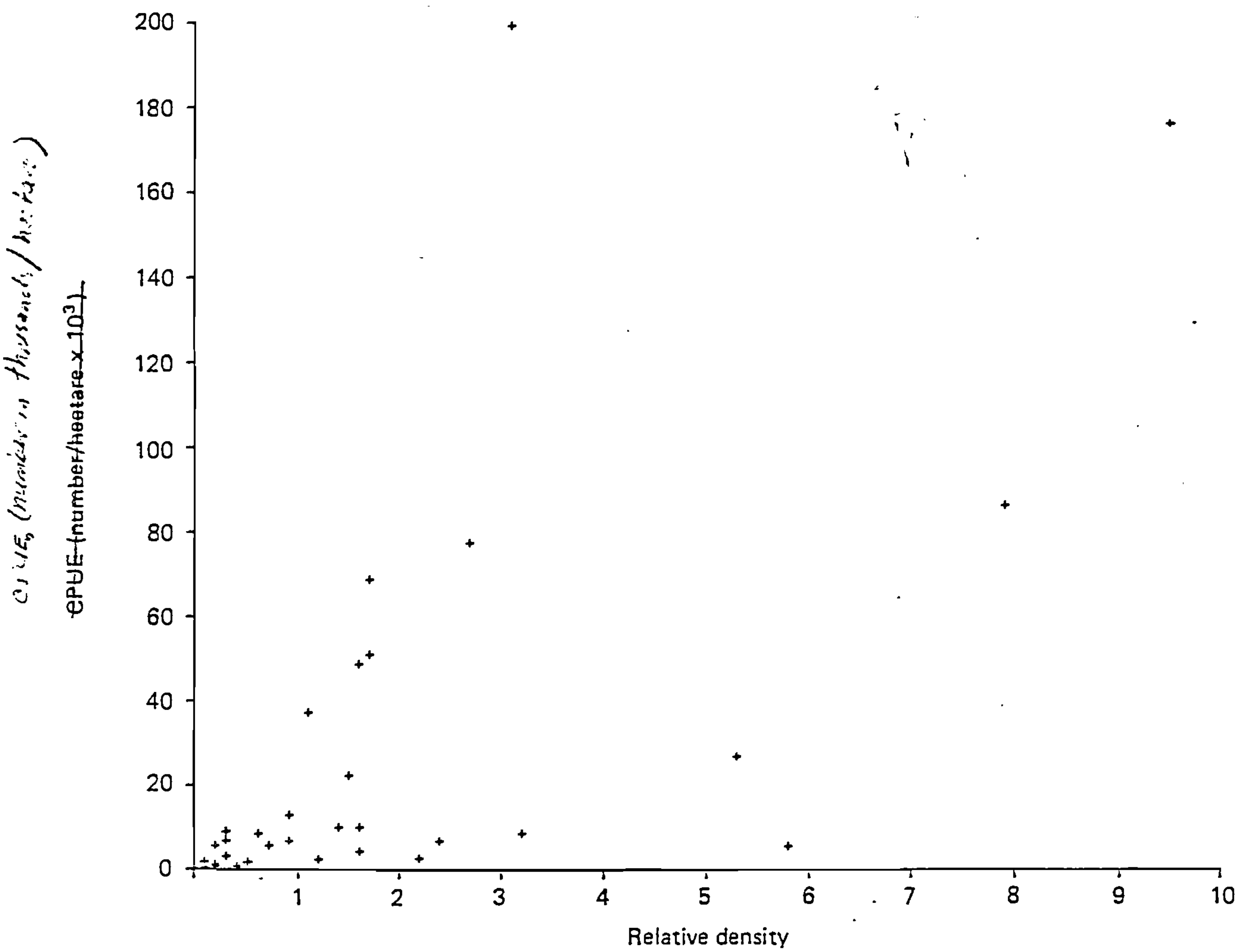
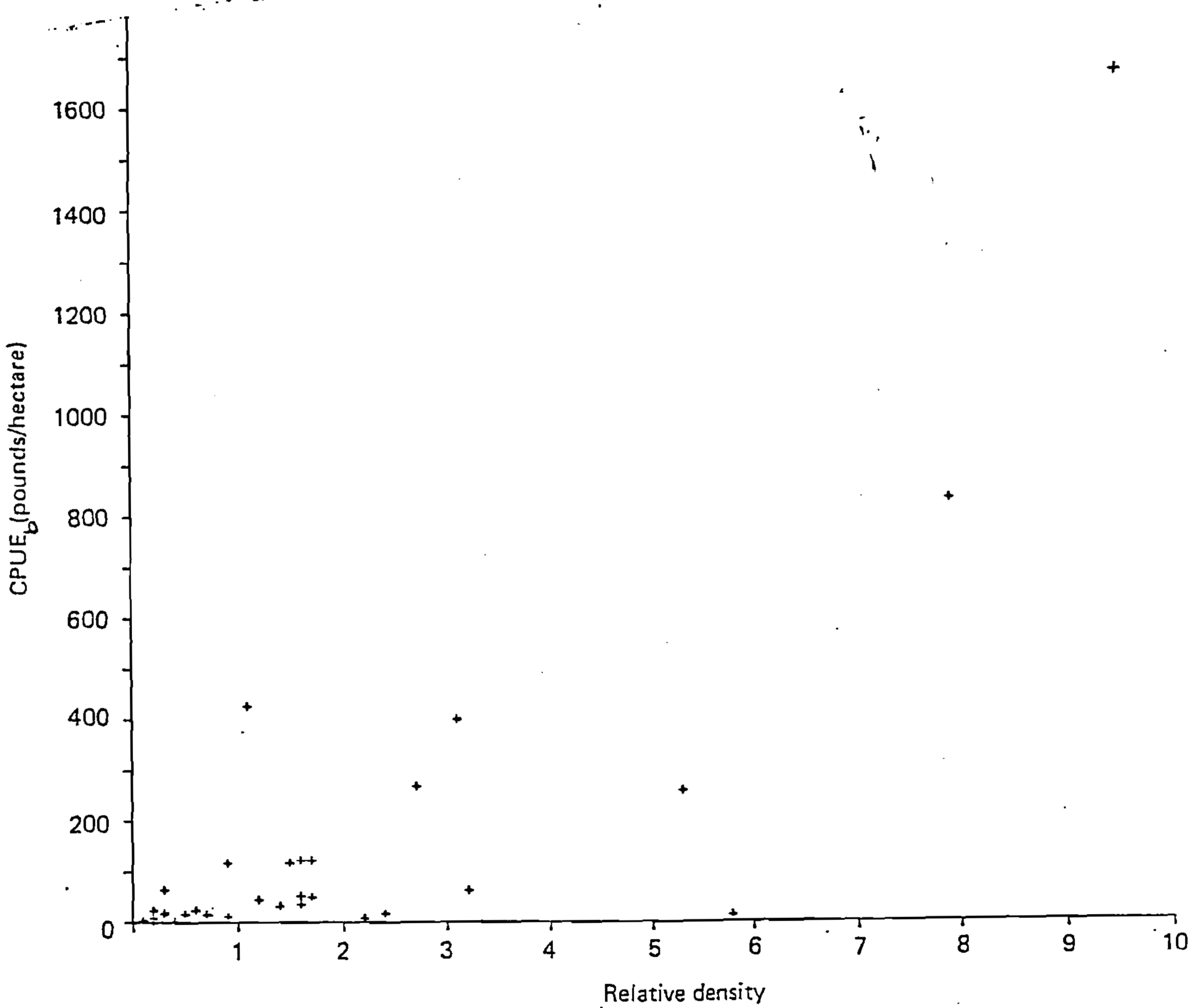
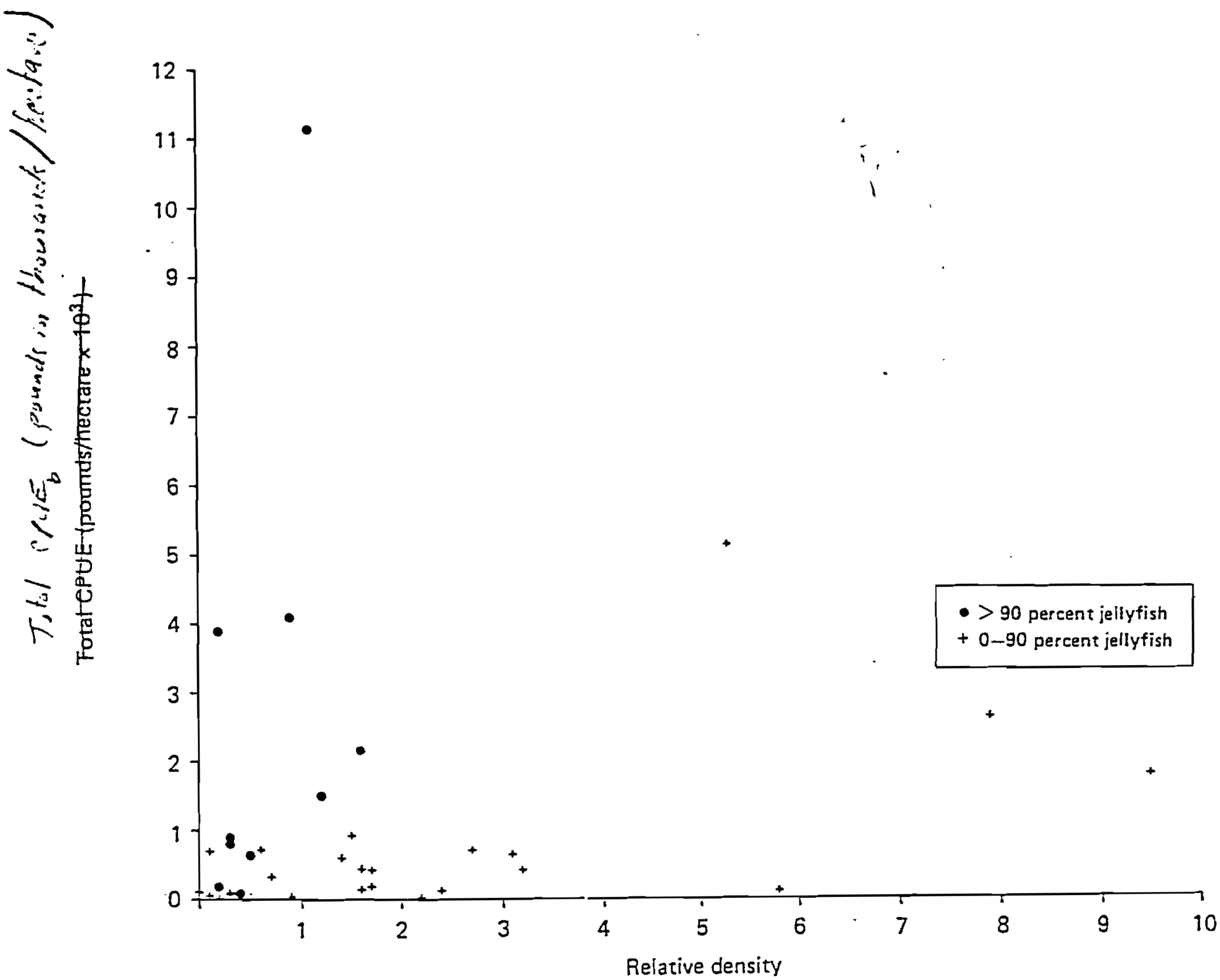

~~CPUE (number/hectare x 10^3)~~
200
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
Relative density

FIG 6



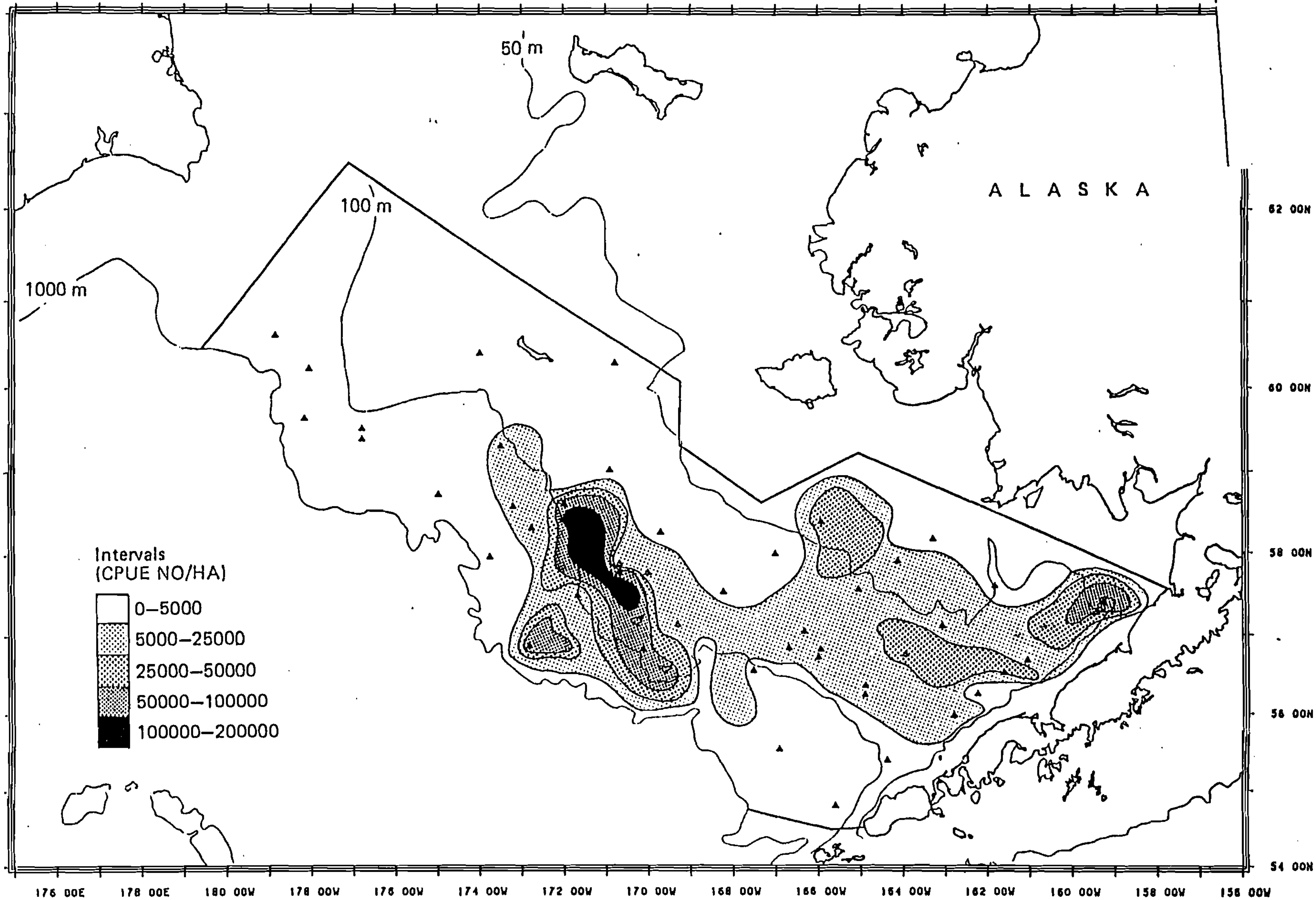
CPUE$_b$ (pounds/hectare)
1600
1400
1200
1000
800
600
400
200
0
1
2
3
4
5
6
7
8
9
10
Relative density

FIG 7



Total CPUE$_b$ (pounds in thousands/hectare)
~~Total CPUE (pounds/hectare x 10³)~~
12
11
10
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
Relative density
● > 90 percent jellyfish
+ 0–90 percent jellyfish

Fig 8



ALASKA
50 m
100 m
1000 m
Intervals
(CPUE NO/HA)
0–5000
5000–25000
25000–50000
50000–100000
100000–200000
62 00N
60 00N
58 00N
56 00N
54 00N
176 00E
178 00E
180 00W
178 00W
176 00W
174 00W
172 00W
170 00W
168 00W
166 00W
164 00W
162 00W
160 00W
158 00W
156 00W

Fig 9

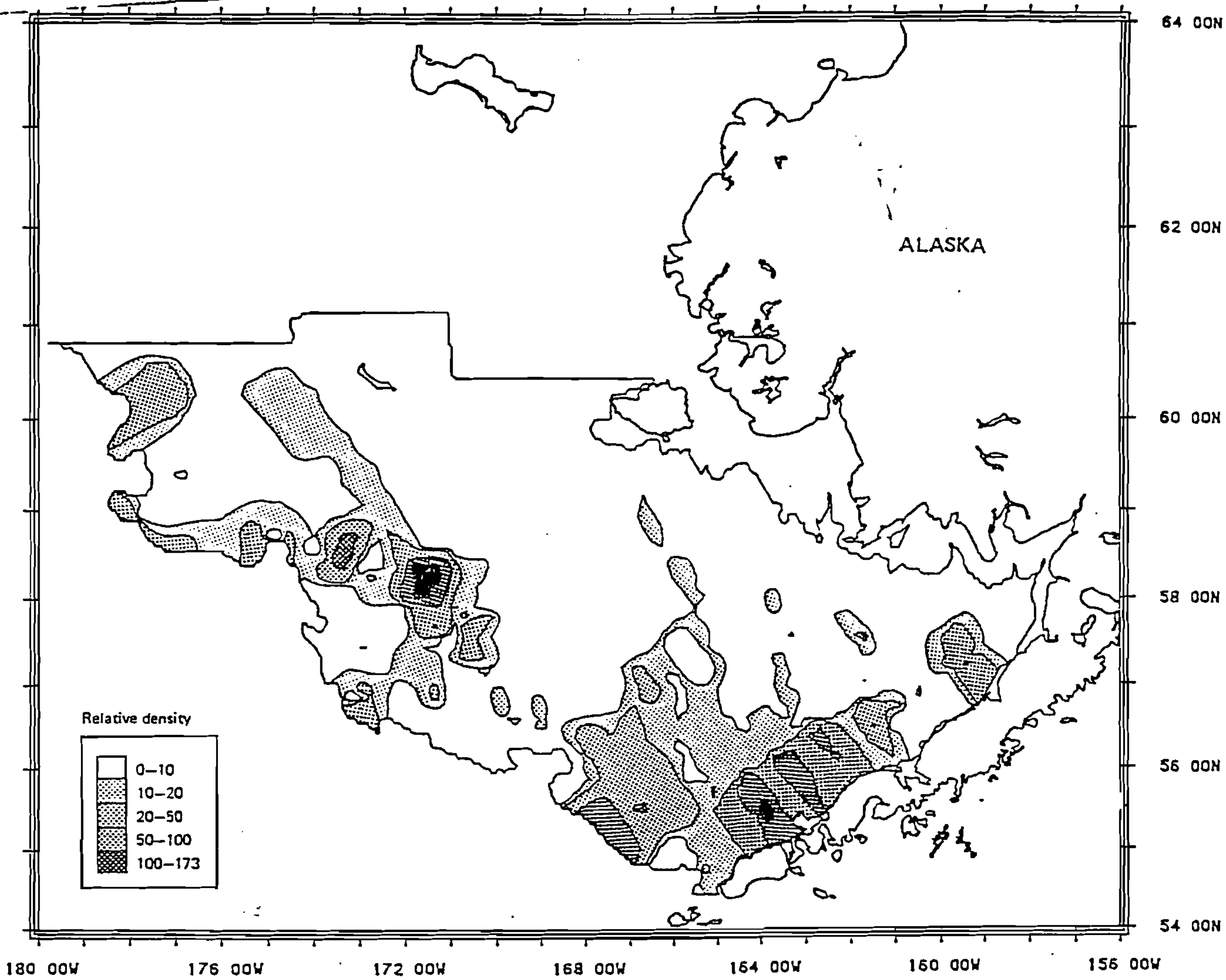
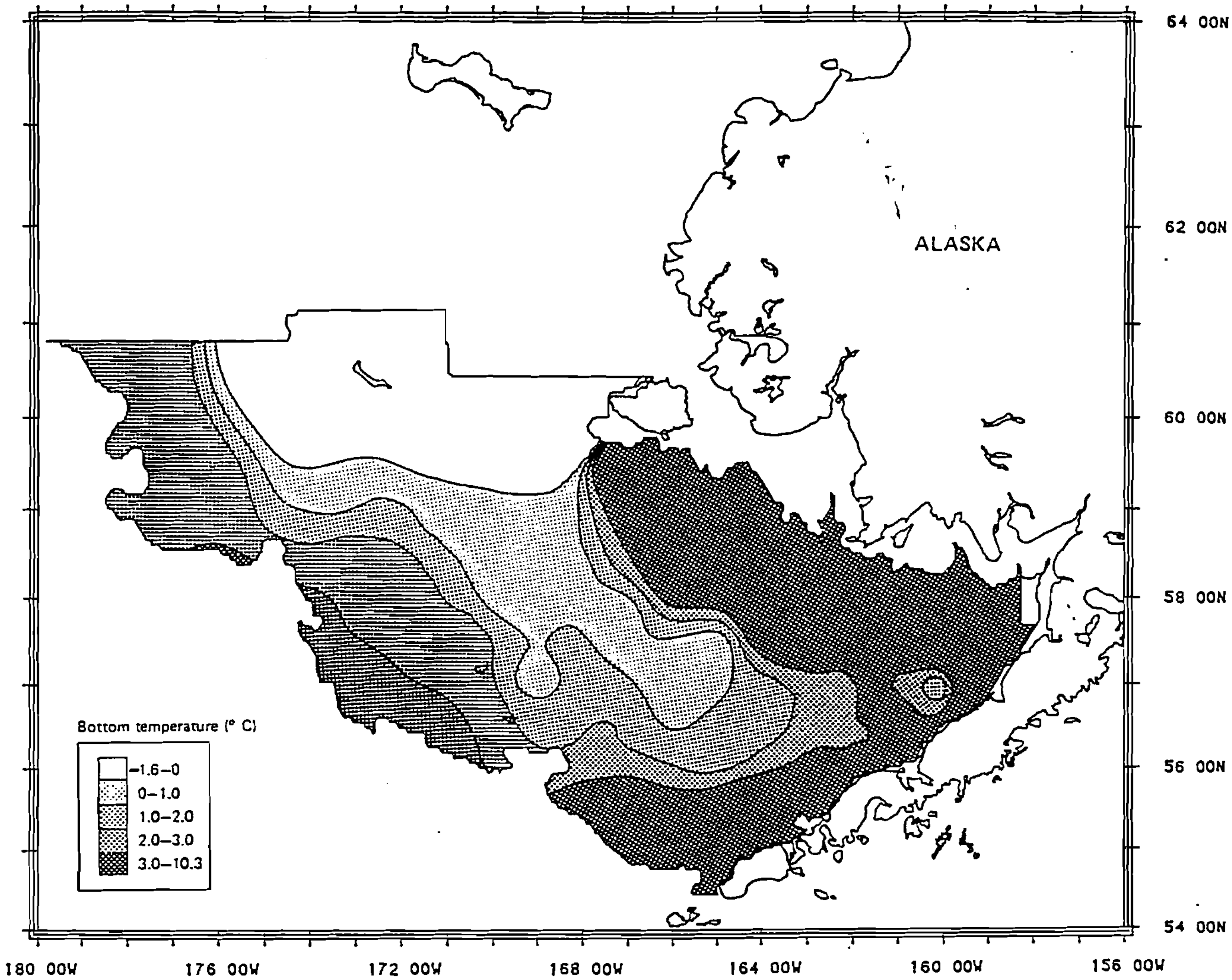
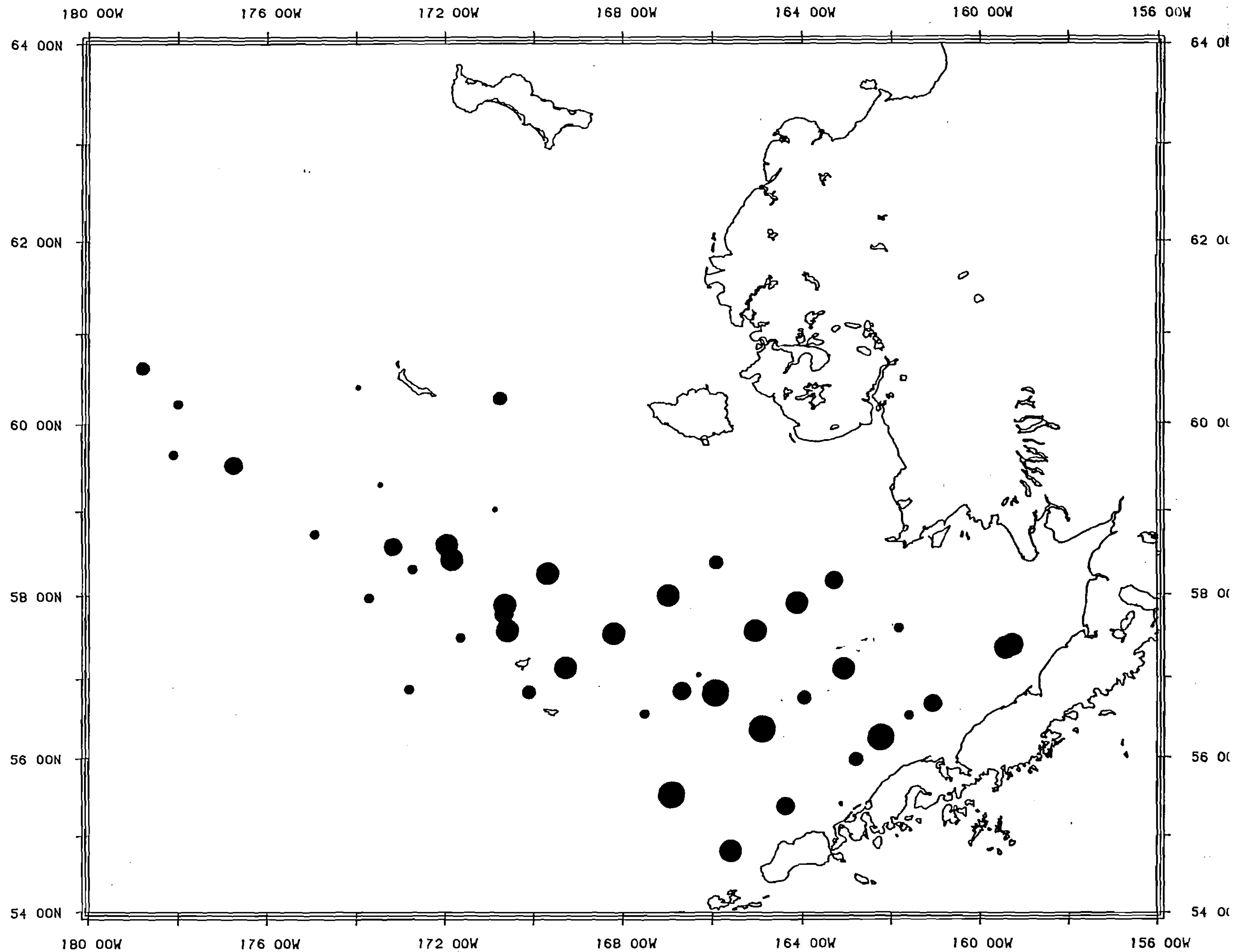

64 00N
62 00N
60 00N
58 00N
56 00N
54 00N
ALASKA
Relative density
0–10
10–20
20–50
50–100
100–173
180 00W
176 00W
172 00W
168 00W
164 00W
160 00W
156 00W

FIG 10


64 00N
62 00N
60 00N
58 00N
56 00N
54 00N
180 00W
176 00W
172 00W
168 00W
164 00W
160 00W
156 00W
ALASKA
Bottom temperature (° C)
-1.6–0
0–1.0
1.0–2.0
2.0–3.0
3.0–10.3


180 00W
176 00W
172 00W
168 00W
164 00W
160 00W
156 00W
64 00N
62 00N
60 00N
58 00N
56 00N
54 00N